All-Sky Monitoring with the Fermi Gamma Ray Burst Monitor

Colleen A. Wilson-Hodge for the GBM Earth Occultation Team, the GBM Pulsar Team, and the GBM team

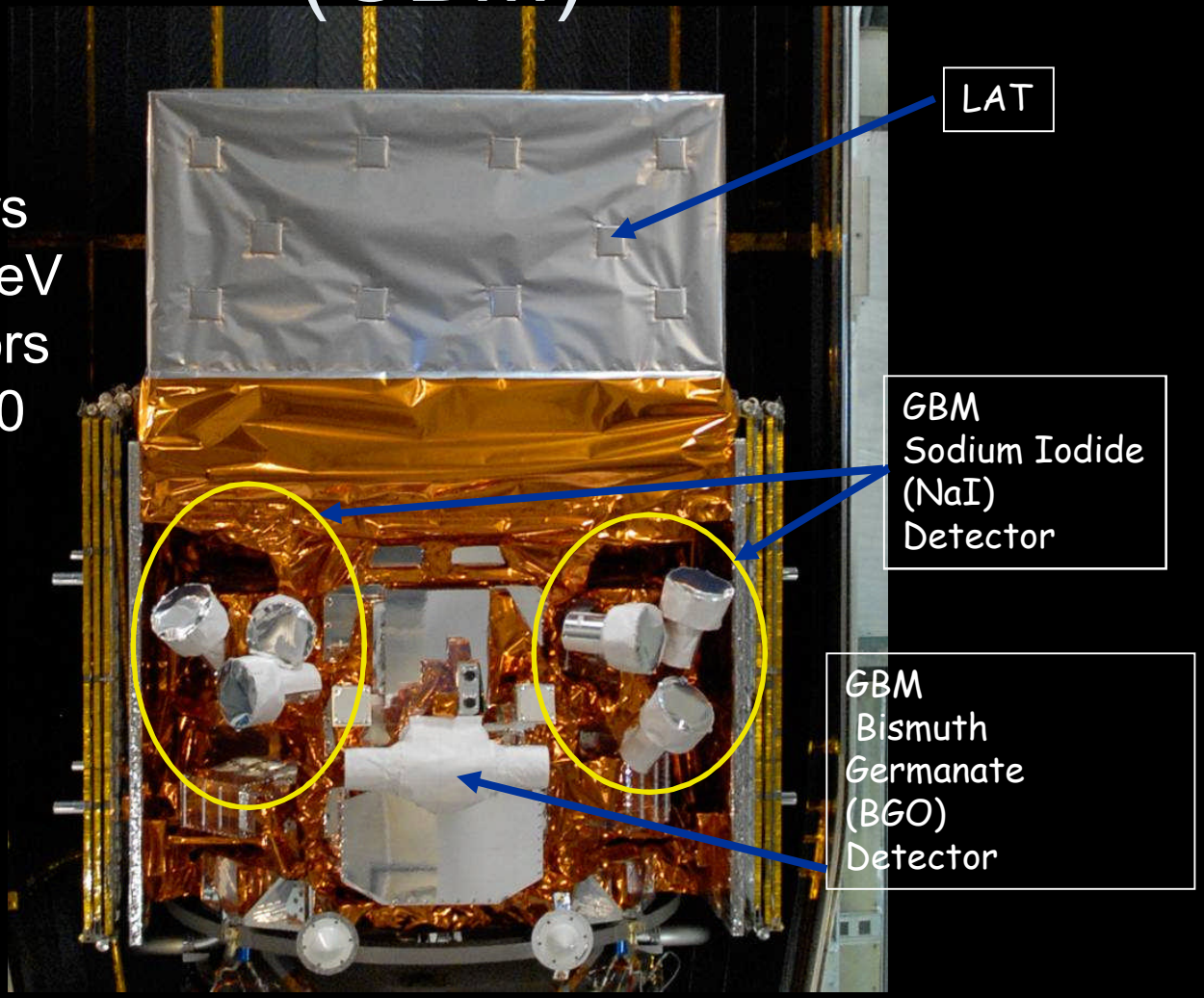
We are currently monitoring the transient hard X-ray/soft gamma ray sky using the Gamma Ray Burst Monitor (GBM) on-board Fermi. The twelve GBM NaI detectors span 8 keV to 1MeV, while the two GBM BGO detectors span about 150 keV to 40 MeV. With GBM, we detect transient events on multiple timescales. Brief events, such as Gamma Ray Bursts, Solar flares, and magnetar bursts are detected with on-board triggers. On longer timescales, we use the Earth occultation technique to monitor a number of sources, including X-ray binaries, AGN, and solar flaring activity. To date we have detected 7 sources above 100 keV. Transient activity from accretion-powered pulsars is monitored using epoch-folding techniques. With GBM we track the pulsed flux and frequency for a number of pulsars. We will present highlights of GBM observations on various timescales.

All-Sky Monitoring with the Fermi Gamma-ray Burst Monitor

Colleen A. Wilson-Hodge (NASA/MSFC) & Valerie Connaughton (UAH) for the GBM Earth Occultation, Pulsar , and Instrument Teams

Fermi Gamma Ray Burst Monitor (GBM)

- GBM
  - 12 NaI detectors
    - 8keV - 1 MeV
  - 2 BGO detectors
    - 150 keV - 40 MeV

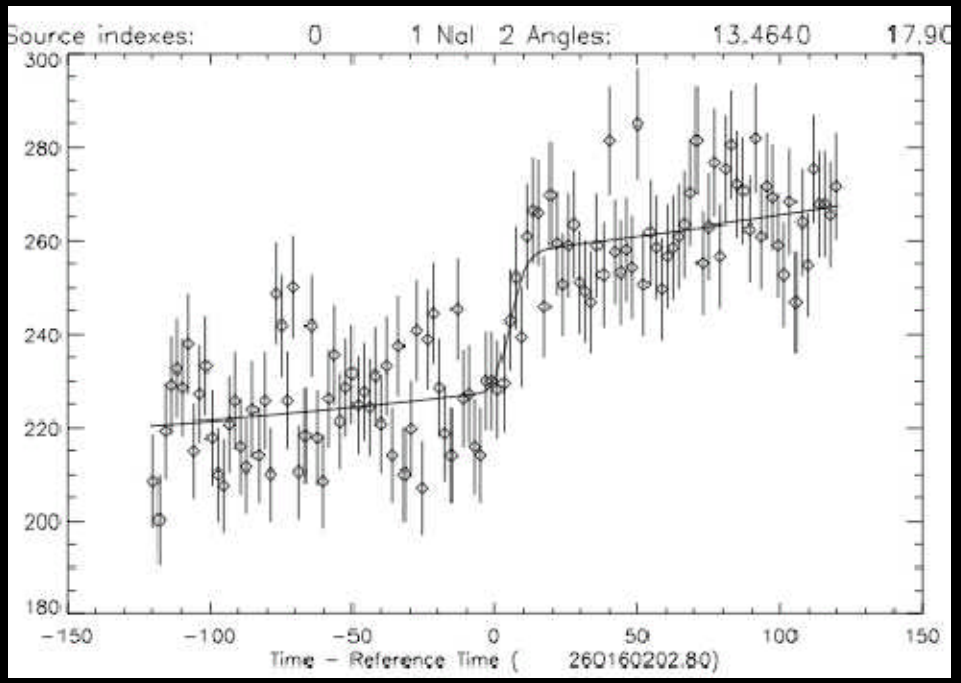


Outline

- GBM Description
- GBM Earth occultation technique
  - Cyg X-1 state transition
- GBM accretion-powered pulsar monitoring
  - 4U1626-67 torque reversal
- Combined Occultation/pulsar results
  - GX 301-2 high spin-up state
  - A0535+262
- Summary
- GBM triggered observations

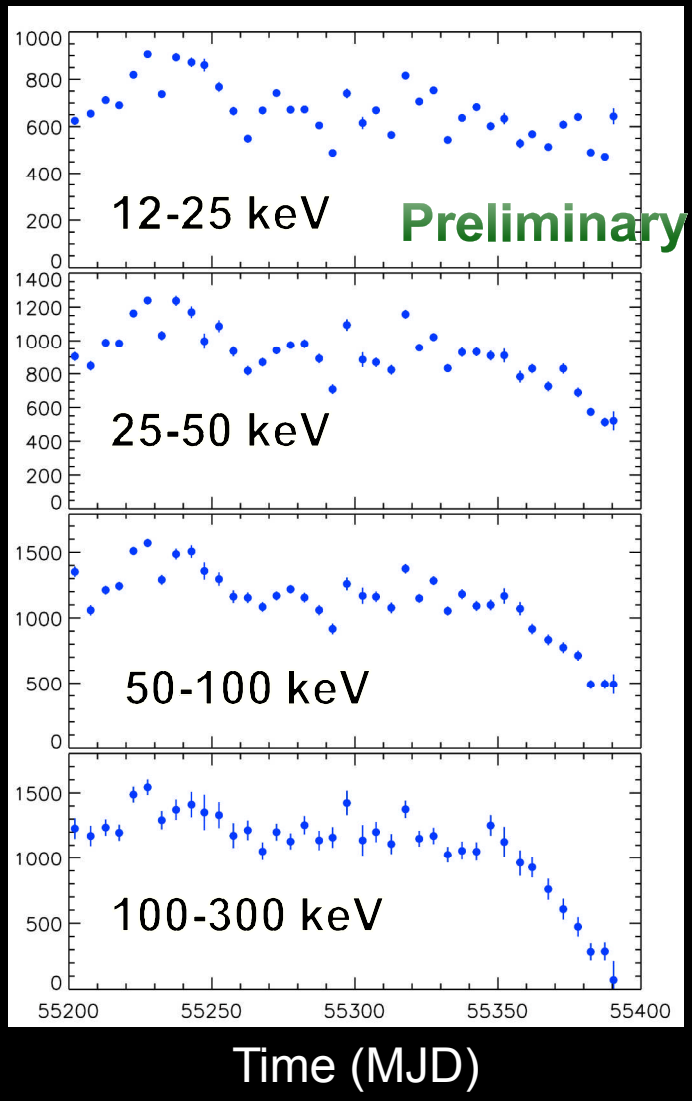
Earth Occultation Technique

- Measures fluxes using the change in count rate due to Earth occultation
- Uses known source positions from a catalog
- Main catalog includes 82 sources, primarily recently active X-ray binaries, 3 AGN, 2 SGRs, and the Sun
- Monitors flux in 8 energy bands in NaI or BGO detectors



- Over 85% of sky viewed every orbit
- Entire sky viewed every ~26 days
- Sensitivity exceeds CGRO/BATSE below 25 keV and above ~1 MeV

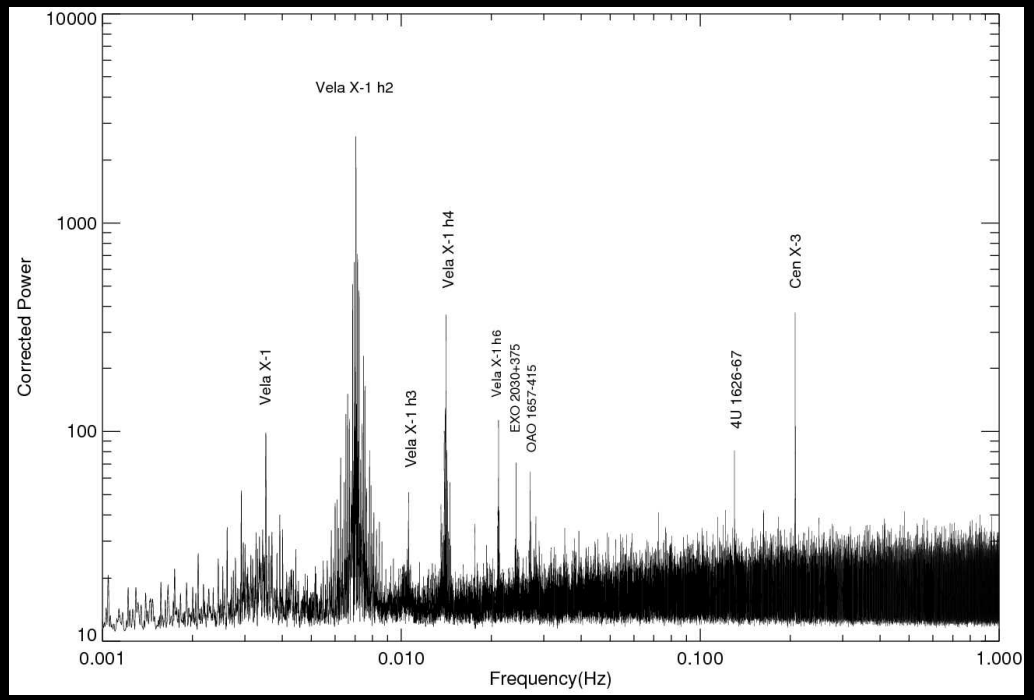
Cyg X-1 State Transition



- Dramatic flux drop observed with GBM in the 100-300 keV band
  - Decline began ~3 June 2010
  - Coincides with 2-10 keV flux increase in MAXI, RXTE/ASM, and Swift/XRT (Atel #2711, 2714, 2715, 2724)
- Leveling off ~3 July 2010
  - Consistent with radio observations confirming soft state ~11 Jul 2010 (Rushton et al. 2010).
  - Resembles 1996 transition when high energy flux declined for about 50 days (Zhang et al. 1997).
- GBM monitoring continues

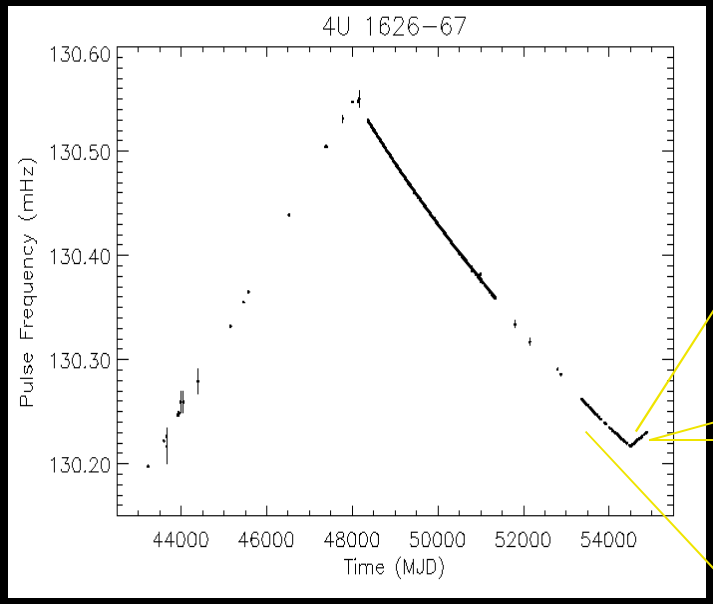
GBM Accretion-Powered Pulsar Monitoring

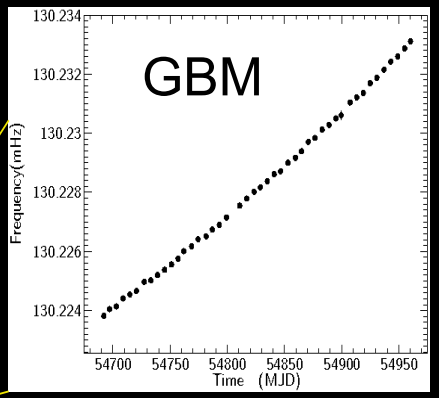
- Daily blind search for pulsed sources
- Source specific analyses for monitoring known pulsars
- Currently monitoring 25 systems
- Typical exposure times are ~40 ks/day. It can be as high as 70 ks

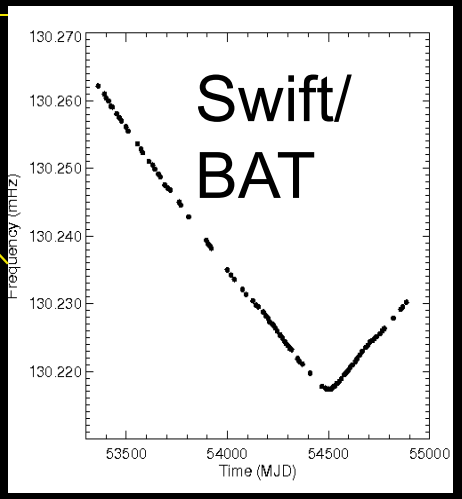


Power spectrum from the GBM blind pulse search for 2010 Jan 8. Power plotted is the maximum over the 24 galactic longitude bins for each frequency.

4U 1626-67 A new torque reversal





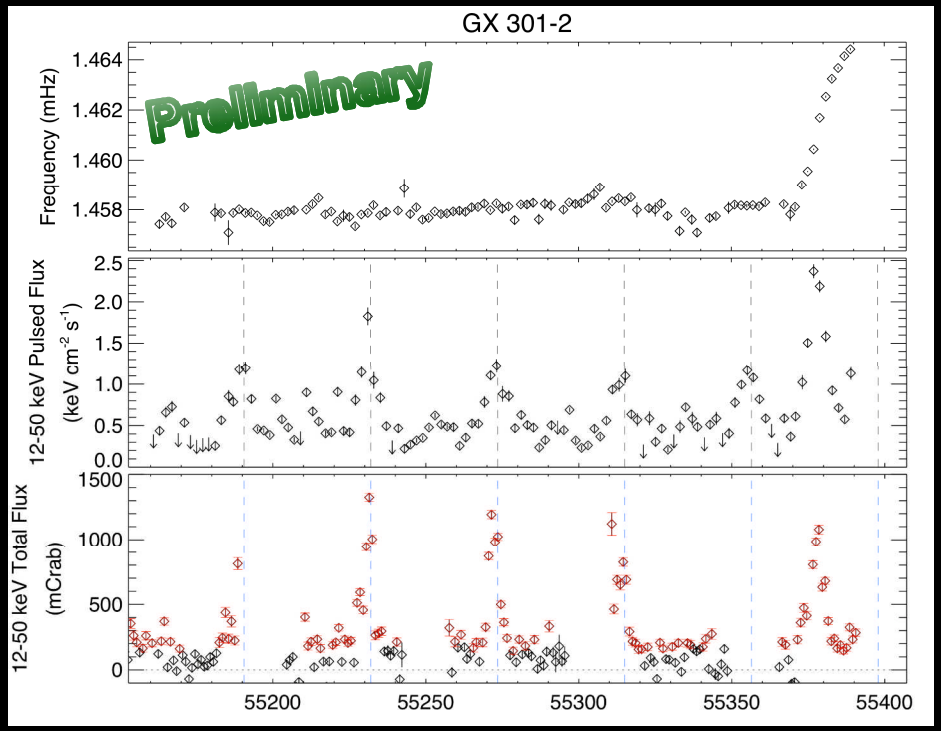


Torque reversal centered in
2008 Feb 4 lasting ~150 days

. LMXRB
. P_{pulse}= 7.66 s
. Ultracompact 42 min orbit.
. Optical counterpart: KZ TrA (V~17.5)
. 48 mHz QPO
. B= (2.4-6.3)x10^{12}G
. Distance 5-13 kpc

Camero-Arranz et al. 2010, "A New Torque Reversal and Spin-up of 4U 1626-67 Observed with Fermi/GBM and Swift/BAT," ApJ, 708, 1500

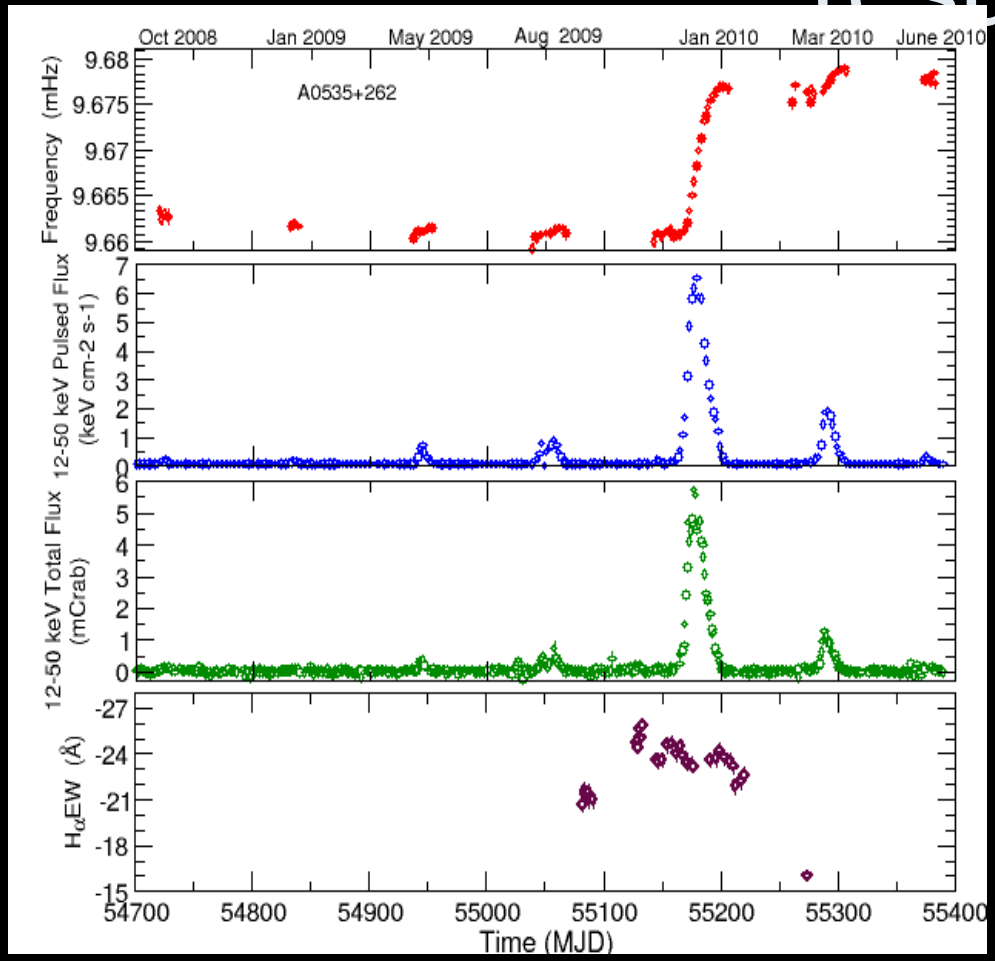
GX 301-2 Rapid Spin-up State



Top: GX 301-2 spin frequency
Center: GX 301-2 12-50 keV pulsed flux
Bottom: GX 301-2 12-50 keV total flux
Dashed vertical lines: periastron passage

- GX301-2 comprises an early B-type companion and a 680 s pulsar
- GX301-2 typically has a bright flare near periastron and a weak flare near apastron.
- GBM detected an unusually bright flare near apastron in ~41.5 day orbit (Atel #□2712)
- This flare coincides with the onset of rapid spin-up beginning 2010 June 25
- The spin period has changed by 3 seconds during the sharp rise.
- This episode of spin-up resembles two episodes observed with BATSE (Koh et al. 1997) and one with GBM in 2009 January.

A 0535+262 X-ray/□□Optical results

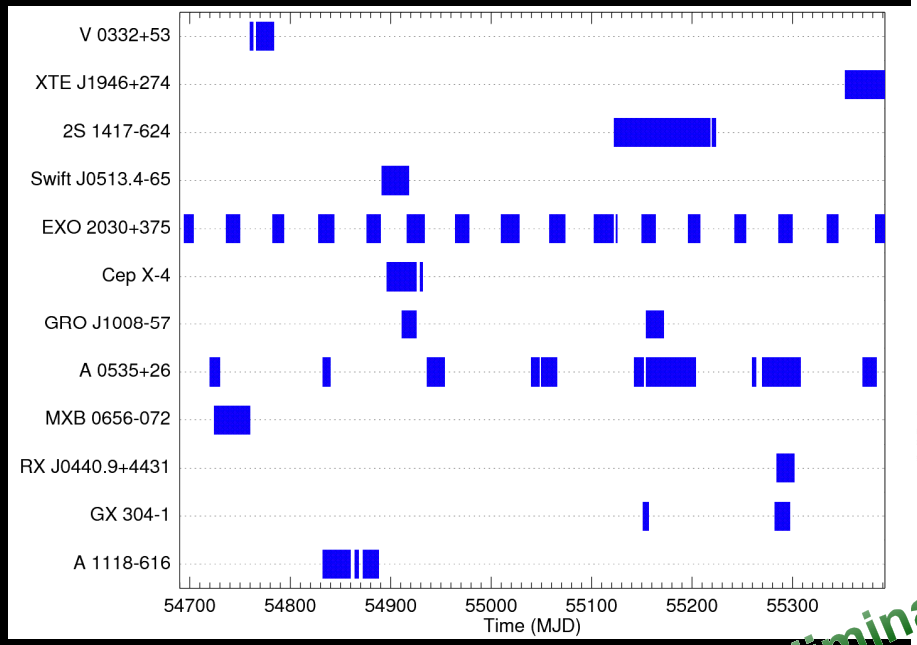


- A 0535+26 is a transient Be/X-ray binary pulsar. The orbital period is ~111 days and the pulse period is □103 s in a eccentric orbit (e □0.47).
- The optical counterpart is the O9.7 Iie star HDE 245770.
- The X-ray intensity of A 0535+26 varies: quiescence with flux levels below 10 mCrab, normal outbursts (10 mCrab-0.5 Crab), and very large (giant) outbursts.
- A 62 mHz QPO was detected by GBM in the 25-50 keV and 50-100 keV energy bands.
- A reduction in the EW of the Hα was observed during the Dec 2009 giant X-ray outburst (the circumstellar disk has grown to its full size before the 2009 giant outburst, and waited for the neutron star to arrive and begin accretion).

Top: A 0535+26 spin frequency
Middle: A 0535+26 12-50 keV pulsed flux
Center: A 0535+26 12-50 keV total flux
Bottom: Hα Equivalent Width (EW) (Liverpool Telescope, La Palma)

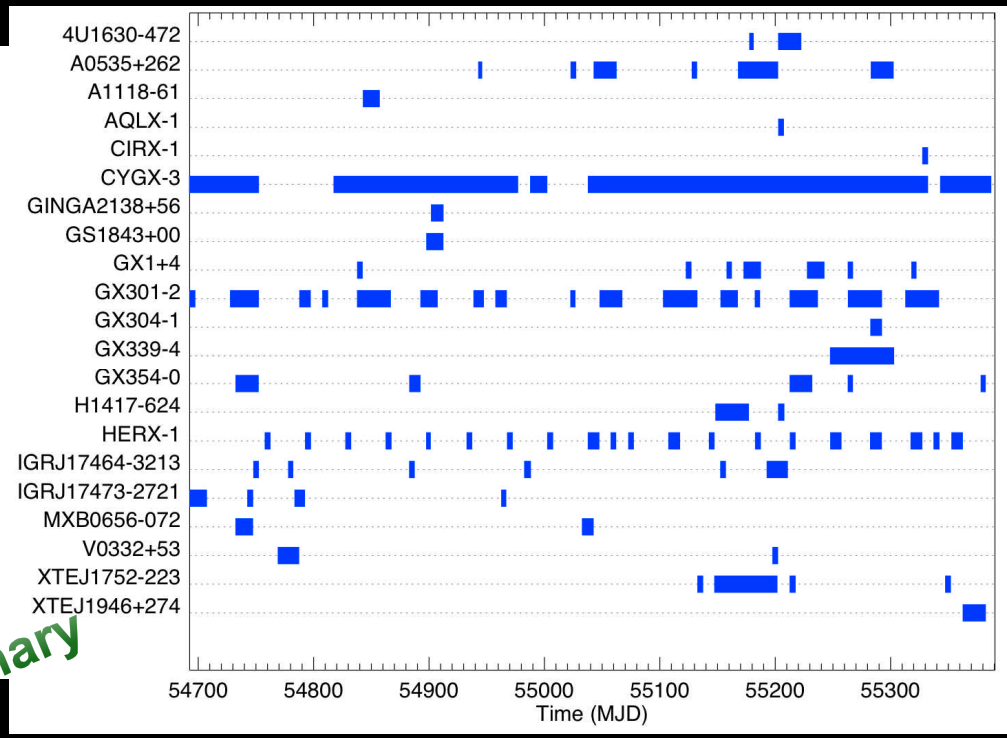
Transient Outbursts

Outbursts seen with Pulsed Detections



Preliminary

Outbursts seen with Earth Occultation



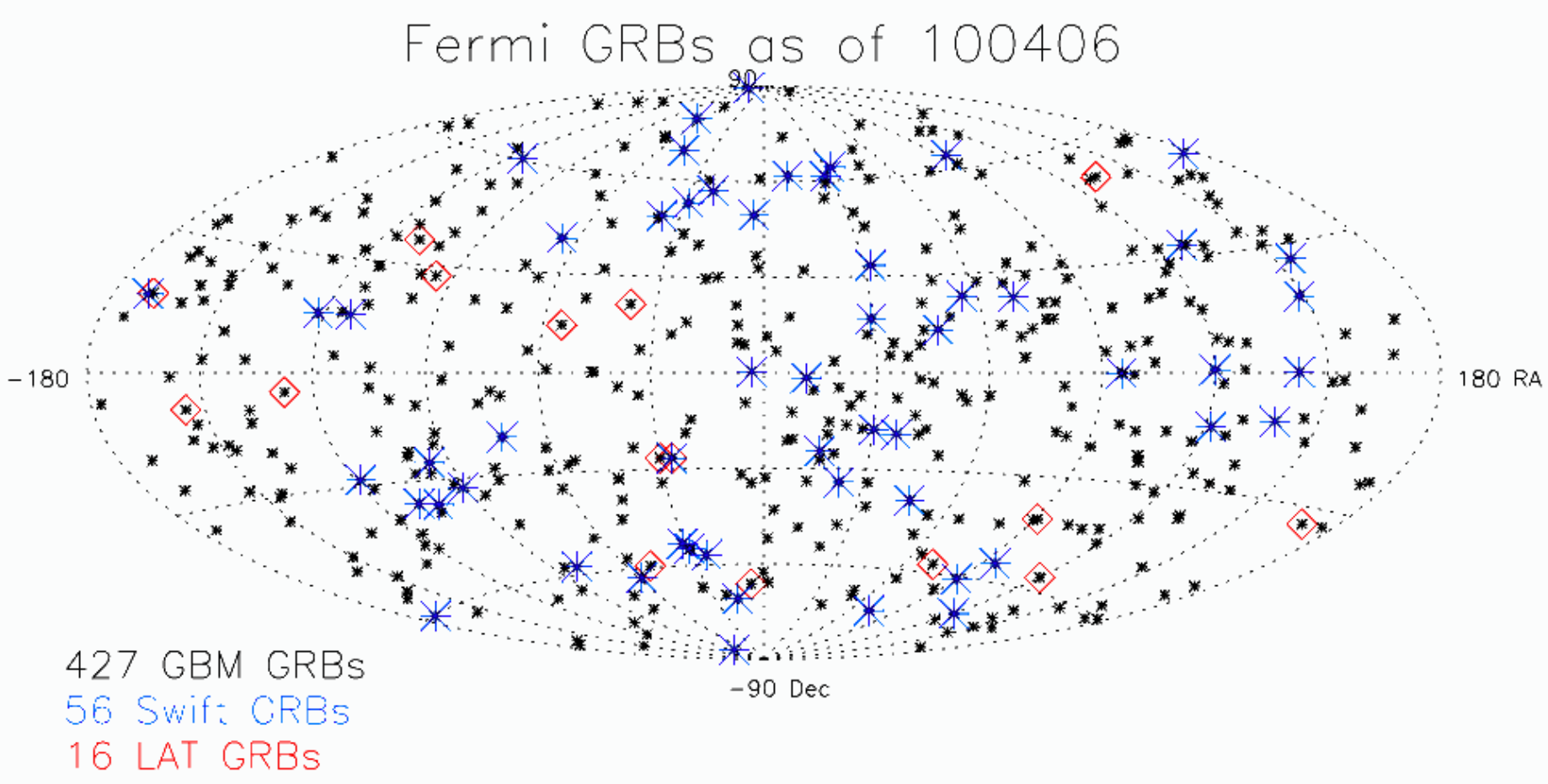
With GBM we see numerous outbursts from transients, including accretion-powered pulsars, black hole candidates, and neutron star binaries

Summary

- Earth occultation monitoring
  - Of 82 monitored sources, 62 detected
  - Dramatic decrease in 100-300 keV flux from Cyg X-1 observed during soft state transition
  - Watch our website for new light curves

  http://gammaray.nsstc.nasa.gov/gbm/science/occultation/
- Pulsed source monitoring
  - 8 persistent sources detected
  - 12 transients detected, 5 (undetected) monitored
  - Rapid spin-up state observed in GX 301-2
  - http://gammaray.nsstc.nasa.gov/gbm/science/pulsar/

GBM Triggered Observations



Current GBM triggers: 503 GRBs, 23 Solar Flares, 81 Terrestrial Gamma Flashes, 169 Soft gamma repeater events